Some Thoughts on Impairment:

An Economic Analysis of the Impairment Standard of the 1996 Telecommunications Act

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Abstract: In this paper, we evaluate using economic analysis the "impairment" standard of the 1996 Telecommunications Act. After defining the "level of impairment" and the "impairment condition," we provide examples of policies and technical realities that satisfy the impairment standard. An economic model of small-numbers competition is used to show how cost disadvantages are translated into reductions in firm output.

I. Introduction

In an effort to affirmatively nudge the local exchange telecommunications market toward a more competitive equilibrium industry structure, the 1996 Telecommunications Act requires incumbent local exchange monopolist to lease elements of their networks to its retail rivals. In determining which network elements should be made available to competitors, §251(d)(2) instructs the Federal Communications Commission to consider, *at a minimum*, whether (A) access to such network elements as are proprietary in nature is necessary; and (B) the failure to provide access to such network elements would impair the ability of the telecommunications carrier seeking access to provide the services that it seeks to offer.

These two criteria are now knows as the "necessary" standard and the "impair" standard. Because the "necessary" standard applies only to "proprietary" network elements, its application is limited. The "impair" standard, consequently, is the more noteworthy standard under which the availability of unbundled elements is to be determined. The purpose of this paper is to share some thoughts, from the general to the specific, on the "impair" standard. The analysis provided here is sufficiently general to apply to any network element.

II. The Impair Standard

Section 251(3)(2)(B) of the 1996 Telecommunications Act requires the FCC "in determining what network elements should be made available … shall consider, at a minimum, whether … the failure to provide access to such network elements would impair the ability of the telecommunications carrier seeking access to provide the services that it seeks to offer." Like much of the Telecommunications Act, the practical implementation of §251(3)(2)(B) required interpretation, and that interpretation was left to the FCC. In its initial Order implementing §251 of the Act ("251 Order"), the Commission defined the impairment standard as:

> …we interpret the "impairment" standard as requiring the Commission and the states, when evaluating unbundling requirements beyond those identified in our minimum list, to consider whether the failure of an incumbent to provide access to a network element would decrease the quality, or increase the financial or administrative cost of the service a requesting carrier seeks to offer, compared with providing that service over other unbundled elements in the incumbent LEC's network (251 Order, ¶284).

This first interpretation of the impairment standard focused on quality and financial differentials caused by a lack of access to unbundled elements. Thus, to the extent a lack of access to a particular unbundled element reduced the quality of CLECs service offering or its profits (i.e., its "financial or administrative costs"), the unbundled element was deemed to satisfy the impairment standard and its availability to CLECs was therefore required.

Dwelling on the implications of the FCC's first effort to define "impair" is unnecessary, since the Supreme Court, in *AT&T Corporation v. Iowa Utilities Board* (1999), rejected the FCC's definition and remanded the issue back to the regulatory agency. The Court declared,

> … the Commission's assumption that *any* increase in cost (or decrease in quality) imposed by denial of a network element renders access to that element "necessary," and causes the failure to provide that element to "impair" the entrant's ability to furnish its desired services is simply not in accord with the ordinary and fair meaning of those terms. An entrant whose anticipated annual profits from the proposed service are reduced from 100% of investment to 99% of investment has perhaps been "impaired" in its ability to amass earnings, but has not *ipso facto* been "impair[ed] … in its ability to provide the services it seeks to offer"; and it cannot realistically be said that the network element enabling it to raise its profits to 100% is "necessary."

The Supreme Court's decision asks the FCC for some limiting standard to its definition of impairment. While cost increases may impair the ability to provide service, the Court concluded it is not necessarily true that *any* cost increase (or margin reduction) impairs that ability in a *material* way. The Court also admonished the FCC for failing to consider directly the available of elements outside the ILECs network, including self-provisioned elements, in its definition of impairment.

The FCC responded to the Court's mandate in its *UNE Remand Order*. In that Order, which still sets the relevant standard for impairment, the FCC defined "impair" as follows:

> … the failure to provide access to a network element would "impair" the ability of a requesting carrier to provide the services it seeks to offer if, taking into consideration the availability of alternative elements outside the incumbent's network, including self-provisioning by a requesting carrier or acquiring an alternative from a third-party supplier, lack of access to that element materially diminishes a requesting carrier's ability to provide the services it seeks to offer (*UNE Remand*, ¶51).

Observe that this new definition of impairment considers only the "ability to provide service" in two-states of the world: one with and one without access to a particular network element. Note also that the FCC avoided including in the definition of impairment any discussion of "cost" or "profit margin," which was no doubt a response by the FCC to the Supreme Court's decision in *AT&T v. Iowa Utilities Board*, as was (no doubt) the phrase "including self-provisioning by a requesting carrier or acquiring an alternative from a third-party supplier." The FCC did not conclude, however, that cost disadvantages, quality differentials, or other factors were irrelevant to impairment. Indeed, it is these factors that allow the agency to assess impairment in the sense that these factors all contribute to an attenuation, at least to some degree, in the "ability to provide service." Section IV of this Policy Paper provides a theoretical discussion of the relationship between the ability to provide service and cost disadvantages.

The FCC's most recent definition of impairment is not much more than a restatement of the plain language of the Telecommunications Act. For the FCC, impairment exists when a "lack of access to that element materially diminishes a requesting carrier's ability to provide the services it seeks to offer." This statement is nearly identical to that of §251(d)(2)(B), which states that an element must be unbundled if "a failure to provide access to such network elements would impair the ability of the telecommunications carriers seeking access to provide the services that it seeks to offer." For the most part, the difference between the two statements is the substitution of the (dictionary) definition of "impair", that is "to damage or make worse by or as if by diminishing in some material respect" or equivalently to "materially diminish," into the language of §251(d)(2)(B).

1. The Impairment Condition

All said and done, the impair standard rests solely on whether or not a lack of access to that element "*materially diminishes*" a requesting carrier's "*ability to provide the services it seeks to offer*." While there are numerous considerations when performing an impairment analysis (cost, timeliness, quality, ubiquity, and operational issues), including the potential for "self-provisioning" or acquiring the element from a "third-party supplier," the deciding factor on impairment is whether or not the *quantity of service* offered by the CLEC is or would be materially diminished by a lack of access to an unbundled element.[1] Clearly, impairment in the "ability to provide service" is most readily detected in the difference in quantity of service provided without and with access to the unbundled element, other things equal.

To give some specificity to the impair standard, let Q_U be the quantity of services sold by the CLEC when it has access to the unbundled element, and let Q_S represent the quantity of services sold without access to the unbundled element. The *level of impairment* (m) is defined as

$$Q_S / Q_U = m, \qquad (1)$$

where the variable m measures the relative size of the CLEC customer base without and with the unbundled element. For example, if the lack of access to the element reduces the CLEC's customer base from 100 customers to 75 customers, then the level of impairment is 0.75 (i.e., $Q_S / Q_U = m = 0.75$). Equation (1) specifies the level of impairment in terms of quantities, but a difference in market share is an equally valid indicator of the level of impairment.

Once the level of impairment is defined and calculated, the next question is whether or not that level of impairment is "material." Materiality is not a highly specific standard, and the FCC has not provided substantial guidance on its bounds. This fact is unfortunate, since the whole notion of impairment rests on its definition. For any particular definition of "materiality", say m^*, the *impairment condition* is

$$m < m^*, \qquad (2)$$

[1] 15 FCC Rcd 3734-3745, ¶¶ 72-100.

or equivalently $Q_S / Q_U < m^*$. Under the most strict interpretation of impairment, $m^* = 1$, so that a CLEC is impaired if $Q_S < Q_U$ (i.e., impairment is satisfied is the CLEC experiences any reduction whatsoever in its customer base by being denied access to an unbundled element). This strict interpretation is perhaps what the Court believed was implicit in the FCC's initial definition of impairment. If a 5% reduction in the quantity of services sold is deemed "material," then $m^* = 0.95$.[2] In this case, a particular element satisfies the impairment standard if a lack of access to the element reduces the ability of a requesting CLEC to provide service by 5%.

As a practical matter, the evaluation of impairment must frequently focus on cost differentials (or differentials in quality, ubiquity, timeliness, etc) caused by access or a lack thereof to an unbundled element. While the impairment condition is a "quantity" condition, it is often difficult if not impossible to assess the quantity effect directly, since data must be produced in two separate regimes -- one with and one without the unbundled element. Such "natural" experiments are rare, but some empirical work has been done in this area.[3]

Importantly, evaluating cost differentials in lieu of quantity changes is perfectly legitimate given that an increase in (marginal) cost always reduces output (i.e., output is a function of costs, $Q = f(C)$, where C is cost and the change in quantity with respect to a change in cost, $\Delta Q / \Delta C$, is negative).[4] A proof of this proposition is found in Jean Tirole's *Theory of Industrial Organization* (1995, p. 66-7), so it is not repeated here.

An analysis of cost differentials is easily incorporated into the definition of the level of impairment, where Equation (1) is simply rewritten as

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[2] If the level of impairment is defined in terms of market share, then the level of m^* must vary according to the initial market share of the CLEC. In the local exchange telecommunications market, however, the ratio of market shares is a reasonable approximation of changes in quantity since the total market output is relatively stable.

[3] See, e.g., *An Empirical Exploration of the Unbundled Local Switching Restriction*, Z-Tel Policy Paper No. 3, Updated March 2002; *Does Unbundling Really Discourage Facilities-Based Entry? An Econometric Examination of the Unbundled Switching Restriction*, Z-Tel Policy Paper No. 4, February 2002; T. R. Beard, G.S. Ford, and T. W. Koutsky, *Facilities-based Entry in Local Telecommunications: An Empirical Investigation*, Auburn University Working Paper, March 2002.

[4] Increases in fixed costs will reduce the number of firms that can profitably serve a market, so fixed costs are also relevant.

$$\frac{Q_U + (\Delta Q_U / \Delta C)\Delta C}{Q_U} = m\,, \tag{3}$$

where $Q_S = Q_U + \Delta Q_U / \Delta C$ and $\Delta Q_U / \Delta C$ is negative. Equation (3) is the equivalent to Equation (1), but defines Q_S is terms of deviations from Q_U based on a cost change.

Importantly, C (the measure of cost) should not be viewed narrowly as a measure of marginal cost but instead a symbolic index of costs. Nor do we expect $\Delta Q_U / \Delta C$ to be a smooth, continuous relationship. Given the sheer magnitude of fixed and sunk entry costs required to self-supply unbundled loops or switching, $\Delta Q_U / \Delta C$ is most likely discontinuous and in many cases may be so large as to reduce output to zero (i.e., $(\Delta Q_U / \Delta C)\Delta C = Q_U$, so output is reduced to zero under self-provision). With substantial fixed costs, average cost will exceed marginal cost by a non-trivial amount.

While we can express the impairment condition in terms of costs without loss of validity, the alternative definition requires some measure of how cost changes impact firm output. That is, will a small (or large) cost differential lead to a "material" reduction in output? For the cost-based impairment analysis to be useful, there should be some method by which to quantify the relationship between quantity and costs (i.e., $\Delta Q_U / \Delta C$), at least loosely. Theoretical and empirical methods are two possible routes to quantify this relationship. In Section IV, we summarize a simple theoretical framework that illustrates generally how cost changes impact firm output. In the following sections, we provide numerous examples of how the impairment condition can be evaluated.

While it is easy to define the level of impairment and the impairment condition, at least generally, designing a practical test for impairment can be difficult. In some cases, we can measure the change in quantities directly, and we do so in the next sections of this paper. In other cases, however, a less direct approach is required where differences in costs (or quality, or ubiquity, etc.) are used to make inferences about differences in quantities. An example of a large cost disadvantage for CLECs is presented in Section III.4. A theoretical discussion of how cost differentials impact relative quantity (or market share) is provided in Section IV. The question of impairment and extant facilities-based entry is addressed in Section V.

III. Examples of Impairment

Conducting an impairment analysis generally will focus on either the assessment of quantity, cost, quality, or other differentials caused by a lack of access to an unbundled element, or group of elements. In this section, a number of applications of the impairment condition are provided, including an example from the FCC's *UNE Remand Order*, which we turn to first.

1. Examples from the UNE Remand Order

In the *UNE Remand Order*, the FCC reiterated its position that CLEC access to unbundled local switching ("ULS") is necessary to realize the pro-competitive goals of the *1996 Telecommunications Act*. Specifically, the FCC concluded "that, in general, lack of access to unbundled local switching materially raises entry costs, delays broad-based entry, and limits the scope and quality of the new entrant's service offerings (¶)."[5] Primary motivators for the FCC decision include the desire "to encourage the rapid introduction of competition in *all* markets, including residential and small business markets (¶9, emphasis added);" to allow CLECs "to serve the *greatest number* of customers (¶10, emphasis added);" and "to benefit *all* Americans by opening *all* telecommunications markets to competition (¶2, emphasis added)." All these concerns reflect a decision based in the impairment condition with the FCC expressing concern with the ability of a CLEC to provide service quickly and broadly.

In evaluating the cost to CLECs of self-supplying unbundled switching, the FCC made (at least) two relevant determinations. First, with respect to colocation, the agency opined:

> … a model submitted by MCI WorldCom that compares the costs of serving residential customers using unbundled elements from the incumbent LEC with the costs of serving the customers using its own facilities indicates that, at low market penetration levels, the costs of collocation would impair a competitive LEC's ability to serve residential customers using its own facilities. The model further demonstrates, however, that using the incumbent LEC's unbundled network elements, the entrant would be able provide service, even at the same low market-penetration levels. Although the model submitted by MCI WorldCom is clearly not dispositive, we note it

[5] It might be better to say that high entry costs are responsible for the delay and limited scope and quality of competitive entry.

> to illustrate that a requesting carrier's ability to serve residential and small business customers may be materially diminished without access to the incumbent LEC's network (UNE Remand, ¶ 82-3).

Further, with regard to the scale economies inherent to telecommunications plant, the FCC stated:

> … competitor's switching costs per minute at a 10% penetration level are slightly more than twice the cost of an incumbent LEC serving the remaining 90% of the market with its own switch. We find that, as a general proposition, requesting carriers will incur a materially greater cost when self-provisioning switching at low penetration levels (UNE Remand, ¶ 260).

Such a sizeable cost disadvantage would no doubt, as the FCC determined, lead to a material reduction in a CLEC's ability to provide service (see Section IV of this paper).

In both of these cases, the FCC's focus was on the impact of scale economies on average cost. No doubt, scale (density, scope) economies are an important determinant of industry structure in the local exchange marketplace.[6] Scale or density economies, however, are not the only source of cost disadvantages, and cost disadvantages are not the only source of impairment. For example, it may be possible to produce a substitute element of substantially inferior quality at roughly equal cost as the element purchased from the ILEC. A substantially quality gap should negatively impact the quantity of service sold by the CLEC.

2. The Hot-Cut Bottleneck

Perhaps the most compelling example of impairment is the hot-cut process. Without unbundled switching, to serve a customer CLECs are required to self-supply switching and lease unbundled loops from the ILEC. The unbundled loop is "hot cut" over to the CLEC's colocation equipment (i.e., physically disconnected from the ILEC's equipment, moved over to and connected to the CLEC's equipment). The hot-cut process is a manual one, and consequently

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[6] See, e.g., T. R. Beard, G. S. Ford, and L. J. Spiwak, "Why ADCo? Why Now? An Economic Exploration into the Future of Industry Structure for the "Last Mile" in Local Telecommunications Markets," *Federal Communications Bar Journal* (Forthcoming 2002; an earlier version of the paper appeared as Phoenix Center Policy Paper No. 12 and is available at www.phoenix-center.org).

limited in its capacity.[7] In fact, the New York Public Service Commission recently opened an investigation into the "hot-cut" process – the "Bottleneck Elimination Task Force" by name -- to consider options regarding how to alleviate the hot-cut bottleneck.[8] In contrast, no such bottleneck exists for the provisioning of UNE-Platform customers, since that process is (in nearly every case) electronic. Indeed, in New York State, an average of nearly 700,000 such transactions occur each month.

The level of impairment can be computed easily in this case. Assume the ILEC provisions, on average, N_P platform customers per month, but has a hot-cut capacity of $\overline{N}_H$ hot-cuts per month. The level of impairment can be measured simply as

$$\overline{N}_H / N_P = m\,. \tag{4}$$

A "material" level of impairment would have to be very large (i.e., m^* is very small) for the hot-cut process to not qualify as a source of impairment. In New York, about 175,000 POTS lines are provisioned monthly to CLECs. Contrariwise, hot-cut volumes average 12,000 installations. Unless the hot-cut process can handle 175,000 installations per month, nearly 15 times the current average volume of hot-cuts, then CLECs are impaired (probably by a substantial amount) without access to unbundled switching.

Another interesting way by which to measure the level of impairment caused by the hot-cut process is to consider the maximum CLEC market share sustainable in a regime where the UNE-Platform is not available. The absolute ceiling on aggregate CLEC penetration for UNE-Platform and UNE-Loop equal

$$UNEP: \frac{N_P}{y}, \qquad UNEL: \frac{N_H}{y}, \tag{5}$$

[7] *See Declaration of Margaret Rubino on Behalf of Z-Tel Communications*, CC Docket Nos. 01-338, 96-98, 98-147, April 5, 2002; *Initial Comments of the UNE Platform Coalition*, CC Docket No. 01-338, 96-98, 98-147, April 5, 2002, p. 44-7.

[8] See *Joint Proposal Concerning Verizon Incentive Plan*, Filed with Letter from Sandra Dilorio Thorn, Verizon, to Honorable Janet Hand Deixler, February 8, 2002, CASE 00-C-1945, p. 4.

where *y* is the monthly churn rate. For New York, we estimate the churn rate for CLECs to be about 7.5% monthly.[9] Over the past two years, Verizon has performed as many as 900,000 POTS migrations. At a 7.5% churn rate and assuming 0.9 million capacity on POTS installations, the maximum sustainable CLEC customer base is about 12 million. Because this "maximum" customer base is about the size of the entire New York switched access line market, there is no effective constraint on CLEC market share with the UNE-Platform.[10] In contrast, over the past-two years, Verizon has performed no more than 20,000 hot cuts in any given month. Even if we double this figure to 40,000 hot cuts in a month, the maximum CLEC customer base is only about 500,000, or less than a 5% market share.

Additionally, Verizon performance data indicates that to maintain the current CLEC customer base of about 2 million access lines in New York, Verizon must perform about 150,000 installations of CLEC lines per month.[11] This is more than 10 times the average number of hot-cuts per month. To support a CLEC customer base equal to 50% of the total market, about 400,000 monthly installations of CLEC lines are required. An important question, therefore, is whether or not Verizon can something near 400,000 hot cuts per month. If not, the hot-cut process alone will satisfy the impairment condition.

Verizon's performance data also shows that of Verizon's 500,000 POTS line installations each month (on average), about 90% of such installations are provisioned electronically, requiring no dispatch. The same is true for UNE-Platform installations. Contrariwise, *every hot-cut requires dispatch*. Thus, without the UNE-Platform, nearly every Verizon installation is performed electronically without dispatch while every CLEC installation is performed manually with dispatch – a substantial asymmetry between Verizon and its

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[9] We measure "churn" in this case as the number of installations provided CLECs as a percentage of total CLEC access lines, which includes ILEC-to-CLEC and CLEC-to-CLEC migrations. This definition is somewhat different than the typical definition of churn, but is a more relevant definition in this particular analysis.

[10] There are approximately 11 million switched access lines in New York State (served by Verizon).

[11] This estimate is based on a least-squares regression with monthly CLEC installations as the dependent variable, and the growth in CLEC customer base and total CLEC customer base as the explanatory variables. Zero-growth installations are computed as the coefficient on the total CLEC customer base (0.07) multiplied by the size of the customer base (about 2.1 million).

competitors. It is thus plain to see (at least part of) Verizon's motivation to eliminate the UNE-Platform.

3. MASS MARKETING COSTS AND GEOGRAPHIC OR CUSTOMER EXCLUSIONS

An entrant to the local exchange marketplace may use mass-market advertising tools – such as television, print, or radio media as well as direct mail and telemarketing -- to acquire customers. These advertising tools involve exposing thousands of potential customers to a "message" in hopes of successfully acquiring as customers some portion of those exposed to the message.

Prior to spending A dollars for a mass market advertisement, the firm must first determine whether or not the payoff from the advertisement (the increased profits) exceed the costs (A). If the advertisement is expected to reach N potential customers, then the expected payoff is the firm's per-unit profit margin multiplied by zN, where z is the percentage of those exposed to the message that purchase the product. Thus, total sales are zN and the average acquisition cost for these customers is A/zN.

Regulations that exclude particular customers from purchasing the product of the firm, such as the FCC's unbundled switching restriction in the largest 50 metropolitan statistical areas, clearly reduce the ability of firms to provide service.[12] The impairment condition, in this case, can be evaluated directly in terms of quantity (though a cost analysis is also straightforward).

As in the case of the unbundled switching restriction, assume that a regulation prohibits the entrant from offering its service to X percent of the N customers exposed to the advertisement. Without the restriction, zN customers respond to the advertisement and purchase the product. That same advertisement, under the restriction, only has a success rate of $(1 - X)zN$, where $(1 - X)$ is non-negative

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[12] See, e.g., Z-Tel Policy Paper No. 4 and Beard, Ford, and Koutsky (2002). It is possible to construe the FCC's switching restriction as an intentional reduction in competition for small business customers by the agency itself. First, competition in the business markets threatens the implicit subsidy scheme from business to residential consumers (to the extent such subsidies exist). As the former FCC Chief Economist once said, "cross-subsidies are the enemy of competition, because competition is the enemy of subsidies (*Prospects for Deregulation in Telecommunications*, May 30, 1997, www.fcc.gov)." Second, Public Choice economics would suggest that the FCC, as a captured agency, is inclined to restrict competition in the more profitable of the ILECs' markets in an effort to protect monopoly rents for expropriation.

and less than or equal to one (i.e., X is a percentage). Clearly, with such a restriction in place, the entrant acquires fewer customers (i.e., XzN fewer customers to be exact), and the level of impairment is

$$(1 - X)zN / zN = (1 - X) = m\,. \tag{6}$$

Since more than 80% of access lines are located within the Top 50 MSAs, restrictions on access to unbundled elements in these markets can reduce substantially a CLEC's ability to provide service (Appendix A).[13]

Further, under this restriction, the per-customer acquisition costs are $A/(1 - X)zN$, which exceeds the unrestricted market acquisition costs by $1/(1 - X)$. In some cases, such a restriction may raise acquisition cost to a level that precludes entry and serves as an absolute entry barrier, as has been the case for some CLECs in the small business market where the restriction is particularly relevant.[14]

4. THE COST OF CAPITAL

In the example above from the *UNE Remand Order*, the FCC relied on evidence that scale economies alone caused impairment. In this section, we perform a similar analysis in which all things are assumed equal except for one: the cost of capital. In the current market environment, CLEC access to capital is extremely limited. For many CLECs, there is no access to outside capital. For others, the cost of such capital is extremely high and, in many cases, too high.[15] Few entry or

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[13] The FCC's switching restriction currently applies only to a subset of access lines in the Top 50 MSAs, though to a large degree the difficulties in managing restrictions on portions of a market exclude entry into the whole market. Some parties, in an effort to reduce competition faced from UNE-Platform CLECs, have recommended various extensions of the restriction. Those potential entrants impeded by the restriction, of course, call for its elimination.

[14] Of course, the switching restriction influences entry decisions in many ways, not just the impact such restrictions have on the efficiency of mass-market advertisements.

[15] In its most recent earning call, Z-Tel CEO Gregg Smith observed: "...where the stock is and where the debt market is, ... we are just going to have to grow the business at the best rate we can given our ability to internally generate cash. ... Until we are able to get money at attractive terms, we are just living out of our checkbook (Z-Tel Technology Earnings Conference Call, 4th Quarter 2001, February 28, 2002)."

expansion barriers are more pernicious than the current lack of access to affordable capital.

To assess the impact of the cost of capital on a CLEC's costs, assume that the CLEC and ILEC are identical in *all* respects, *except* the CLEC has a higher weighted-average cost of capital.[16] Assume that input prices and efficiencies of ILEC and CLEC are identical. To produce its output Q_C, the CLEC needs one input. This input is either self provisioned with capital expense F or purchased as a UNE from the ILEC at price R. Capital expense F is converted into an annual carrying cost with factor k. There are no other costs, for simplicity.[17] The average cost per-unit for the CLEC is:

$$AC_C = k_C F / Q_C \, , \tag{7a}$$

if the input is self-supplied, or

$$AC_C = R = k_I F / Q_I \, , \tag{7b}$$

if the input is purchased as a UNE. Note that R is equal $k_I F/Q_I$, or TELRIC (given the assumption of no other costs), where k_I is the capital charge factor for the ILEC and Q_I is the ILEC's total output (assumed to be equal to that of the CLEC, though scale economies could be evaluated as well by allowing Q_i to differ between the two).

Considering the impairment condition of Equation (3), the difference in cost between self-supply and UNEs is measured as the difference between Equations (7b) and (7a), or

$$\Delta C = \frac{F(k_C - k_I)}{Q} \, . \tag{8}$$

In this simple example, the CLEC will self-supply if $k_C - k_I \leq 0$ (i.e., ΔC is non-positive).

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[16] We might view this difference in capital costs as being driven by a firm's life-cycle, with high risk in early periods but more stable risk in maturity.

[17] To the extent there are, these costs are assumed to be equal across CLEC and ILEC (or, at least, proportional).

Moving now to an estimate of the annual carrying charge for firm i (k_i), observe that

$$k_i = \frac{1 - A(n, r_i)t/n}{(1-t)A(n, r_i)} \tag{9}$$

where $A(n,r_i)$ is the present value of a \$1 annuity computed over n years at rate r_i, and t is the tax rate. Note that r_i is the only variable that varies across firms, and that

$$r_i = dc_{d,i} + er_{e,i} \, / \, (1-t) \tag{10}$$

where d is the percent of total capital that is equity, e is the percent of total capital that is equity, and $r_{d,i}$ and $r_{e,i}$ are the returns on debt and equity for firm i. To provide some specificity, assume that the UNE in this analysis is unbundled local switching. For digital switching, the FCC's Hybrid Proxy Cost Model ("HPCM") specifies an economic life of 16.43 years (n) and a tax rate (t) of 39.25% (again, assumed equal across firms). The cost differential between self-supply and UNEs can be determined by estimating the cost of capital, r_i, for each firm.

Cost of Capital for ILECs

BellSouth, Verizon, and SBC make up the comparables for estimating the cost of capital for the ILECs. Over the past five years, AAA-rated and A-rated Public Utility bond yields have exceeded the risk-free rate (10-year Treasury Bond) by about 187 basis points on average. In December 2001, the 10-year Treasury yield was 5.09%. Thus, the cost of debt for the ILECs is 6.96%, if we ignore short-term debt costs (to simplify).[18]

The CAPM is used to estimate the cost of equity capital. As of March 2002, the average Beta (five-year) of the three comparables was 0.46 (BellSouth 0.40; Verizon 0.51; SBC 0.48).[19] The market-risk premium is assumed to be 6.6%, which

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18 Short-term debt amounts to about 25% of total debt for the Bell Companies. For the Bells, short-term debt (commercial paper) generally carries a lower yield than long-term debt.

19 Beta values are provided by www.marketguide.com (values as of March 2002).

is the average market-risk premium recommended by three popular finance textbooks.[20] With these inputs, the ILEC cost of equity is

$$r_{e,ILEC} = 5.09 + 0.46 \cdot 6.6 = 8.13\%. \tag{11}$$

The FCC's HCPM assumes 44.2% of total capital is debt. With this capital structure, the after-tax weighted average cost of capital is

$$r_{ILEC} = 0.442 \cdot 6.96 + \frac{0.558 \cdot 8.13}{1 - 0.3925} = 10.55\%. \tag{12}$$

Whether or not one accepts the level of these estimates, these standard financial methods (frequently used in UNE cost proceedings) illustrate that the cost of capital for the CLECs is substantially greater than the cost of capital for the ILECs. Choosing a different absolute level for the cost of capital while maintaining the relative levels between ILEC and CLEC will not materially alter the results (over the reasonable range of r).

Cost of Capital for CLECs

For the CLECs, Allegiance Telecom, RCN Corporation, and Time Warner Telecom make up the comparables. To estimate the cost of debt faced by these firms, we compute the yield spread between each company's last reported bond issue and the contemporaneous risk-free rate (10-year Treasury). The average yield spread over the 10-year Treasury for these companies was 532 basis points. Given the current risk-free rate of 5.09%, the cost of debt for the CLECs is estimated to be 10.41%.

As of March 2002, the average Beta of the three comparables was 3.28 (Allegiance 3.83; RCN 2.19; Time Warner Telecom 3.83). With a risk-free rate of 5.09% and a market-risk premium of 6.6%, the CLEC cost of equity is estimated to be 26.65%.

Given of capital structure of 44.2% debt and 55.8% equity, the weighted average cost of capital for CLECs is

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[20] Aswath Damodaran, *Damodaran on Valuation*, 1994; Tom Copeland, Tim Koller, and Jack Murrin (McKinsey & Company, Inc.), *Valuation*, 2000 (3rd Edition); and Richard Brealey and Stewart Myers, *Principles of Corporate Finance*, 2000.

$$r_{CLEC} = 0.442 \cdot 10.41 + \frac{0.558 \cdot 26.65}{1 - 0.3925} = 29.08\% \,. \tag{13}$$

This cost of capital for the CLECs is about 2.5 times larger than that of the ILECs.

Capital Carrying Costs

Armed with estimates of r_i, the capital charge factors can be computed. Using Equation (9), the capital charge factor for the ILECs is

$$k_I = \frac{1 - A(16.43, 10.55) \cdot 0.3925/16.43}{(1 - 0.3925) \cdot A(16.43, 10.55)} = 0.126 \,. \tag{14}$$

For the CLECs, the capital charge factor is

$$k_C = \frac{1 - A(16.43, 29.08) \cdot 0.3925/16.43}{(1 - 0.3925) \cdot A(16.43, 29.08)} = 0.273 \,. \tag{15}$$

The relative (capital) cost disadvantage faced by CLECs is sizeable. For any given investment, the cost disadvantage is

$$\Delta C = \frac{F(0.273 - 0.126)}{Q} = \frac{0.147F}{Q} \,. \tag{16}$$

Because 0.147 exceeds 0.126, the cost disadvantage itself exceeds the average cost of the ILEC. Or, stated another way, the cost of self-supply is more than twice as high as the cost of the UNE. In this simple model, however, other expenses and the intensity of capital use have been ignored. In the next section, these cost of capital estimates are used in a more complex and realistic simulation.

Simulating the Effect on Costs

Simulating the cost effects of differences in the cost of capital can be performed with the FCC's HCPM. Specifically, by substituting the estimates of capital costs into the HCPM, the per-line costs for loops and switching can be computed. For convenience, the computation of per-line cost for loops and switching mirror those used by the FCC in its Pennsylvania 271 Order. For these illustrative calculations, the loop and switching costs for New York State are computing first using the cost of capital estimate for the ILEC and second for the CLEC. The results of this simulation are not much affected by the choice of state.

For unbundled analog loops, our cost of capital estimates for the ILEC produce an estimated monthly cost of $8.78. Monthly switching costs are computed to be $3.07 for the ILEC. Alternately, at the CLEC's cost of capital, the monthly cost for the loop is $14.98 – a 71% cost differential. Switching cost for the CLEC are $4.83, or 57% higher than the ILEC. While these cost disadvantages are sizeable, they do not reflect any other differences between the ILEC and CLEC such as cost differences based on differences in input prices or scale, density, or scope economies. What this analysis suggests is that for both loops and switching, the CLECs disadvantages in the capital markets is sufficient to support impairment for all unbundled elements that require a capital investment of nearly any magnitude.

IV. Cost Disadvantages with Small Numbers Competition

There are a number of ways to evaluate the theoretical relationship between cost changes and output. One particular approach, perhaps best suited for the impairment analysis, is to evaluate the impact of cost differences within some framework of small-numbers competition. Specifically, the analysis in this section is based on duopolistic competition in which the two firms behave as Cournot competitors. Bertrand and perfect competition will be considered later in this section.

For the Cournot duopoly, let market demand be

$$P = a + b(Q_1 + Q_2), \qquad (17)$$

where P is the market price, Q_i is the output of firm i. Note that total industry output, Q, is equal to $Q_1 + Q_2$. Further, assume that firm 1 has marginal cost C_1 and firm 2 has marginal cost λC_1, where λ measures the cost disadvantage of firm 2 (i.e., $\lambda \geq 1$). In the case of identical firms ($\lambda = 1$), each firm has a market share (w_i) equal to 50% of the equilibrium market output Q^*.[21] As λ gets larger, however, firm 2's market share declines while firm 1's market share increases.

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[21] For firm i, equilibrium output is $[a + (c_j - 2c_i)] / 3b$, and market output is $(2a - c_j - c_i) / 3b$.

Total industry output also declines. Our focus, however, is only on the reduction in firm 2's market share.

Specific assumptions regarding the parameters a, b, and C_i can be avoided by defining the impairment conditions as

$$w_S \,/\, w_U = m\,, \tag{18}$$

where impairment is expressed in terms of market share of firm 2 (w) rather than output.[22] Note that in our simple model, w_U = 0.50.

Additionally, it can be shown that for some price-cost margin k, the market share of firm 2 is zero (i.e., firm 1 monopolizes the market) when the cost disadvantage of firm 2 (i.e., λ) is

$$\lambda^0 = \frac{2+k}{2(1-k)}, \tag{19}$$

where λ^0 indicates the value of λ that reduces firm 2's market share to zero. The figure in Table 1 illustrates the relationship between firm 2's market share and λ.

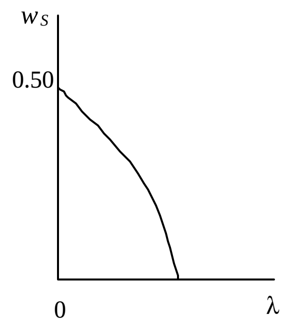
Observe in Table 1 that the relationship between firm 2's market share (w) and λ is non-linear (i.e., the curve is concave). Table 1 also summarizes the values for λ^0 at different values of k. Assuming a price-cost margin of 40%, Table 1 shows that λ^0 is 2.00, and at a cost disadvantage of 50% (λ = 1.50), firm 2's market share is approximately 28% (the relationship is non-linear, though the assumption of linearity does not terribly distort the actual market share).[23]

[22] It is certainly possible to measure the quantity differentials, but the parameters of cost and demand will influence the absolute values.

[23] The actual market share is 28.5%, so a linear approximation has an error of 3.5 percentage points of market share at λ = 1.5.

Table 1. Market Share with a Cost Disadvantage

k	λ, w_S	λ^0, w_S	λ, w_S
40%	1.0, 50%	2.00, 0%	1.50, 28%
30%	1.0, 50%	1.64, 0%	1.32, 28%
20%	1.0, 50%	1.38, 0%	1.19, 28%
10%	1.0, 50%	1.17, 0%	1.08, 30%



Even across the broad range of margins (10% to 40%), the firm's output is very sensitive to cost disadvantages. According to the FCC's own estimate, the margin for local, analog voice service (based on average cost, which in this model is equal to marginal cost) is about 24% on average.[24] At this margin, firm 2's market share is zero when λ is 1.47 (i.e., $\lambda^0 = 1.47$). In this case, a mere 25% cost disadvantage ($\lambda = 1.25$) reduces firm 2's market share by 23 percentage points, or 45%.

This simple Cournot simulation illustrates that as a matter of theory, small cost disadvantages can lead to substantial reductions in service provided. Thus, when analyzing cost in an impairment analysis, even small increases in costs can lead to sizeable reductions in service provided. Even for margins as high as 40%, the elasticity of market share with respect to the cost disadvantage is about -1.00 (suggesting a 10% increase in cost leads to a 10% reduction in market share). As the margin declines below 40%, the elasticity becomes even larger. The elasticity also becomes larger as the cost disadvantage becomes larger.[25]

Other Forms of Competition

If the two firms behave as Bertrand competitors, the equilibrium market price is equal to marginal cost (assuming no fixed costs). For any value of λ exceeding 1,

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[24] The FCC's margin calculation is outlined in the New York 271 Order, ft. 1332. The average margin of 24% is based on the FCC's calculations for all states and the District of Columbia, excluding Alaska and Hawaii, and is computed using 2000 ARMIS data.

[25] Because the relationship between market share and the cost disadvantage is concave, at higher values of λ, small changes in λ produce large changes in market share.

the market share of firm 2 is driven to zero. In other words, monopoly is the product of any cost disadvantage whatsoever. Under a Bertrand scenario, therefore, any increase in cost satisfies the impairment condition because any increase in cost eliminates the firm altogether. Generally, as the intensity of price competition increases so does the level of impairment for a given cost differential.

V. Impairment and Extant Facilities Deployment

In the *UNE Remand Order*, the FCC reiterated its position that CLEC access to unbundled local switching ("ULS") is necessary to realize the pro-competitive goals of the *1996 Telecommunications Act*. Despite this finding, the FCC did place a restriction on CLEC access to unbundled local switching. Specifically, in the *UNE Remand Order,* the FCC chose to remove the unbundled switching obligations of the ILECs for customers with more than three switched access lines in the densest portions (density zone 1) of the fifty largest Metropolitan Statistical Areas ("MSA"), as long as the ILEC provided access to enhanced extended links in these areas. This restriction deliberately precludes the provision of competitive services to consumers with more than three access lines by CLECs using ILEC local switching and UNE-Platform.

The FCC restricted access to unbundled switching in these particular geographic areas because the FCC conjectured, based on the scant evidence available at the time, that self-provision might be possible and profitable. The ULS restriction rested almost exclusively on the observation that a few CLECs were self-provisioning switching in the dense markets:

> … to the extent that the market shows that requesting carriers are *generally providing* service in particular situations with their own switches, we find this fact to be probative evidence that requesting carriers are not impaired without access to unbundled local circuit switching (¶ 276, emphasis added).

This conclusion contrasts sharply with the FCC's conclusion in that same Order that "…the ability of *one or more competitors* to serve certain customers in a particular market *is not dispositive* of whether competitive LECs without unbundled access to the incumbent LEC's facilities are able to compete for other customers in the same market or for customers in other markets (¶54, emphasis added)." The FCC did add a caveat of economic viability to its discussion, noting that "it is too early to know whether self-provisioning is economically viable in the long run, although capital markets appear to be supplying requesting carriers with access to capital in the absence of demonstrated profitability (¶ 256)." Given the rash of CLEC bankruptcies subsequent to the *UNE Remand Order*, it is no longer "too early to know" whether self-provisioning is economically viable: for most CLECs, self-provisioning was a failure.

The FCC's consideration of the extent of self-supply appears at first glance to be a reasonable application of economic reasoning. If a few firms are doing something, how can other firms be impaired from doing so as well? However, basic economic theory illustrates the potential problem with the FCC's reasoning.

To illustrate the point in a familiar context, consider the case of providing interexchange services. Today, CLECs are not "impaired" in the provision of interexchange service because an active and competitive wholesale market exists in interexchange facilities. What if a wholesale interexchange market did not exist, despite the presence of five nationwide networks? The FCC's "generally providing" logic implies that the presence of (say) five nationwide networks is "probative evidence" that any CLEC could build the sixth network irrespective of the fact that entry into the interexchange industry requires substantial capital expenditures for which the current and expected levels of demand are insufficient to justify economically. Further, the economies of scale inherent in interexchange facilities are ignored. Clearly, the existence of capacity in a market does not imply additional capacity is profitable, or even that the existing capacity is profitable.[26]

Basic economics tells us that when sunk costs must be incurred upon entry, the number of entrants is limited (see below). The FCC alludes to this economic fact in the *UNE Remand Order*:

> … where an incumbent has already deployed sunk facilities to serve all customers, a competitive LEC may be unwilling to sink the costs of duplicative facilities, either because it may be unable to lure customers away from the incumbent and generate enough revenue to recover these sunk costs, or because resulting competition between itself and the incumbent LEC would drive prices so low that, even if the competitive LEC won a significant number of customers, it would still be unable to recover its sunk costs (¶ 77).

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[26] The financial troubles of interexchange wholesalers like Global Crossing, Williams, Level 3, Qwest, and even MCI-Worldcom suggest the possibility of over-supply in the wholesale interexchange market.

Clearly, the FCC understands that sunk costs limit entry, either due to their absolute level relative to market size, or due to the extent of price competition.

We can interpret the (somewhat hypothetical) interexchange example above in terms of the *equilibrium* number of competitors. Given market size, price competition, and sunk costs, the *equilibrium* number of firms is equal to five carriers. By definition, the entry of a sixth carrier is unprofitable and that entry would result in an unsustainable industry structure. Consequently, exit by one market participant must occur to return the industry to an equilibrium configuration.

The same logic applies to local switching. Observing that there are five CLEC switches in a local market in no way indicates that it is profitable for any given CLEC to deploy the sixth. If the existing switching capacity is not used to supply a wholesale market (i.e., all capacity is used by the deploying carrier), then the extent of competition will be limited to the capacity of the five switches. In effect, the ULS restriction re-established a firm link between the number of competitors and sunk costs – a link specifically broken by the unbundling provisions of the *Telecommunications Act of 1996*. Thus, the rule limiting wholesale availability of the local switching element should *reduce* competition in the restricted markets, and empirical evidence supports this expectation.[27]

To illustrate the concept of equilibrium industry structure, and the impact of sunk costs on market structure, consider a two-stage game in which each of a number of potential firms decides whether or not to enter the market in the first stage of the game where entry requires *setup costs* that are sunk (κ).[28] At the second stage of the game, those firms that have entered engage in price competition.

Let the demand curve be $Q = S/p$ where Q measures the quantity demanded for a product or service which for present purposes is assumed to be homogeneous; p measures the unit price of the product or service; and S measures total consumer expenditure on a product or service at a specific time and is *independent* of market price. S also provides a measure of *market size* and quantity demanded for

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27 *See* Z-Tel Policy Paper No. 3.

28 *See* John Sutton, *Sunk Costs and Market Structure*, 1991; Jerry B. Duvall and George S. Ford, *Changing Industry Structure: The Economics of Entry and Price Competition*, Phoenix Center Policy Paper No. 10, April 2001 (www. phoenix-center.org).

the market is simply $Q = \Sigma q_i = q_i \cdot N$, where N is the number of firms. Since this market demand function has a constant, unit own-price elasticity (the demand curve is isoelastic), it can be shown that the profit-maximizing monopoly price approaches infinity for any marginal cost greater than zero. For analytical convenience, it is assumed that sales fall to zero above some cutoff price p_m. Thus, p_m corresponds to the profit-maximizing monopoly price.[29]

Suppose N facilities-based carriers decide to enter the market in State 1 of the game. The profit function of a representative firm i in Stage 2 of the game is given by $\pi_i = (p(Q) - c)q_i$, where q_i is firm i's level of output and p is market price, which is a function of total market output $\{p = p(Q)\}$, and c is marginal cost, which for convenience is assumed constant across all output levels. Setting $q_i = q$ for all i (all firms are identical), it is straightforward to show that the Cournot-Nash equilibrium price is

$$p = c\left\{\frac{N}{N-1}\right\} \tag{20}$$

unless p exceeds p_m, i.e., the price at which sales become zero, in which case $p = p_m$ (the monopoly price).[30] See Duvall and Ford (2001) for a more general, conjectural variation analysis of this model.

At equilibrium market price p, equilibrium output per firm is $q_i = S / Np$. Firm i's profit, therefore, is $\pi_i = S/N^2$. Assuming S or market size is constant, profits realized are clearly dependent on the number of competitors, N, that enter the market and the intensity of price competition (ϕ). For a fixed level of the intensity of price competition, equation (1) shows that as the number of firms increases, the equilibrium level of profit approaches zero.

Turning now to the first stage of the game, the entrant's *strategy* in the game takes one of two forms: (1) do not enter; or (2) enter, incurring sunk costs κ, and

[29] For the isoelastic demand curve, sales are positive regardless of price so that the monopoly price is undefined.

[30] In the Cournot model, rival firms choose the quantity they wish to offer for sale. Each firm maximizes profit on the assumption that the quantity produced by its rivals is not affected by its own output decisions. The Cournot equilibrium asserts that prices and quantities approach competitive levels as the number of firms supplying the market increase.

set *output* at the second stage of the game as a function of the number of firms that enter the market at the first stage. The entrant's *payoff* is either zero (if the firm chooses *not* to enter), or else it is equal to the profit earned at the second stage of the game. The net profit of firm *i* is

$$\{S/(M+1)^2\} - \kappa \tag{21}$$

where M is the number of other firms choosing to enter. Entry occurs if the net profit is positive, and continues in Stage 1 of the game until profits just equal the sunk cost of entry. The number of firms in equilibrium is the integer part of

$$N^* = \sqrt{S/\kappa} \tag{22}$$

where N^* and $1/N^*$ is the *equilibrium* level of concentration.[31] Note that the equilibrium number of firms N^* is a positive function of market size (S), but a negative function of the level of sunk entry costs (κ).

This simple model reveals the economic foundations of the *Telecommunications Act*'s unbundling requirements. Reducing sunk costs by making unbundled elements available to CLECs lowers the equilibrium level of concentration (i.e., promotes competition). While the *Telecommunications Act* aimed to increase competition, regulation also can increase sunk entry costs and, as a consequence, increase equilibrium industry concentration. In the U.S. cable television industry, for example, the level playing field laws of some states requires the entrant to incur identical sunk investments as the incumbent, a requirement that raises entry costs and deters entry.[32]

In addition, regulation and competition policy can influence market size (S). Limited access to subsidies, for example, creates asymmetry between the

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[31] Because we have assumed all firms are identical, $1/N^*$ also is equal to the Herfindal-Hirshmann Index. Bertrand competitors will force price down to marginal cost so that each firm realizes a loss equal to the sunk investment in setup costs, κ. Bertrand price competition implies, therefore, that only one firm enters the market in the first stage of the game and sets a profit-maximizing monopoly price in the second stage, so long as setup costs are greater than zero. See Duvall and Ford (2001) for a conjectural variation version of this model.

[32] Hazlett and Ford (2001) provide a conceptual and empirical analysis of the effects of the level playing field laws in cable television. See Thomas W. Hazlett and George S. Ford, "The Fallacy of Regulatory Symmetry," *Politics & Business*, Vol. 3:1, April 2001.

potential markets of entrants and incumbents.[33] Similarly, the restriction on unbundled local switching limits the ability of potential entrants to serve this particular (and related) local exchange markets and customers, shrinking the available market and increasing concentration. This issue was addressed in Section III.3.

Equation (22) clearly illustrates the problem with the presumption that because other firms have entered a market, additional firms can do so as well. First, if N^* firms have entered the market, then an additional firm cannot because then the profits of all firms ($N^* + 1$ firms) are negative. Second, if we observe N' firms in a market, the first question is whether or not $N' > N^*$. If this condition holds, then exit must occur. Recent experience in the CLEC industry (i.e., widespread failure and bankruptcy) suggests that facilities-based entry by CLECs may have exceeded the existing equilibrium level of such entry.

VI. Conclusion

The 1996 Telecommunications Act requires the incumbent local exchange carriers to offer to their retail rivals elements of the local exchange network as unbundled elements. Which network elements are to be unbundled is determined primarily by the "impair standard" set forth in §251(d)(2) of the Act. In this Policy Paper, the impairment standard is discussed within the context of some simple concepts. The link between impairment and cost disadvantages, a frequent measure of the impact of a lack of access to particular network elements, is provided through a simple model of small-numbers competition. In addition, a few examples of factors most likely satisfying the impairment standard are provided and discussed in some detail.

General conclusions from the analysis include: a) even small cost disadvantages can lead to substantial output reductions; b) in the current market environment, nearly any element that can be replaced only with capital expenditures satisfies the impairment standard; c) basing availability of elements using particular

[33] As noted by Professors Baumol, Panzar, and Willig, in their classic treatise, *Contestable Markets and the Theory of Industry Structure* (1988): "… subsidies are likely to protect incumbent firms from competition, since they are artificial handicaps which must be overcome by entrants who are not eligible fro them. Such problems can be overcome, partially, by earmarking external subsidies to specific activities rather than to specific firms. … In a system following this design, private demands for the goods or services in question are simply supplemented by the demands of the public sector that are expressed in the market through the subsidy scheme (p. 362)."

customer groups and geographic regions most likely violates the impairment standard; d) the hot-cut process no doubt materially diminishes the ability to provide service by CLECs, implying the access to unbundled switching is necessary; and e) the fact that some CLECs have deployed facilities is not a reliable indicator that another CLEC is not impaired in its "ability to provide service" by a lack of access to a particular unbundled element.

Appendix A.

In order to estimate the number of phone lines in a metropolitan area versus non-metropolitan areas, a dataset was collected, by state, including total switched access lines (*LINES*), metropolitan population (*METRO*), and non-metropolitan population (*NONMETRO*). The final sample consisted of 49 states (Alaska was excluded) and the District of Columbia.

A least squares regression was estimated of the form

$$LINES = \alpha_1 METRO + \alpha_2 NONMETRO + \varepsilon$$

where ε is the econometric disturbance term. The coefficient α_1 measures the additional number of switched access lines per additional person living in a metropolitan area. Similarly, the coefficient α_2 measures the additional number of lines per additional person living in a non-metropolitan area.

The estimated regression equation is

$$LINES = 0.728 \cdot METRO + 0.130 \cdot NONMETRO + \varepsilon$$

which has a Pseudo-R^2 of 0.99. The Pseudo-R^2 is the square of the correlation coefficient between *LINES* and the predicted value of *LINES* from the regression and is used because a constant term in not included in the regression. The estimated equation indicates that each additional person in a metro area increases the total number of switched access lines by 0.728 lines, whereas each additional person in a non-metro area increases the number of lines by 0.130.

This regression demonstrates that the market excluded by the MSA restrictions on unbundled switching is not proportionate to population. Using the estimated coefficients from the regression, the percent of total switched access lines in an MSA can be estimated. The results of this estimation are presented in Table A-1 below. The estimated percentage of lines in a metropolitan area (y), given x percent of the population living in that metropolitan area, is:

$$y = \frac{0.728 \cdot x}{0.728 \cdot x + 0.130 \cdot (1 - x)}$$

where the parameters are the estimated coefficients from the regression. Table A-1 summarizes the relationship between the percent of population and the percent of access lines for the larger MSAs.

Table C-1. Percent of Population by MSAs

MSA	Percent of U.S. Population (*x*)	Percent of Switched Access Lines (*y*)
Top 50 MSAs	58%	88%
Top 75 MSAs	64%	91%
Top 100 MSAs	68%	92%
Top 125 MSAs	71%	93%
Top 150 MSAs	74%	94%

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